BCSC 4126 SIMULATION & MODELING

ASSIGNMENT ONE (1)

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Questions

a) Explain why random sampling is necessary in simulation experiments (4 marks) \.

1. ***For Variability***

   Random sampling enables variability reduction ensuring variations within data are appropriately captured. Many systems inherit this for example patient arrival times and service durations.

2. ***Facilitates Statistical Analysis and Inferences***

   By using random samples, it is possible to apply statistical techniques for analysis allowing researchers to draw valid and reliable inferences about a population or system leading to more reliable conclusions.

3. ***Unbiased Representation***

   It allows a fair selection across different possible outcomes ensuring that the simulation results are unbiased leading to more reliable and generalized results.

4. ***Enables the 'What If' Analysis***

   With random variables, a simulation can test different scenarios and conditions by altering random variables thus helping to understand a system's behaviour under varied inputs

b) Dr. Mkubwa is a dentist who schedules all her patients for 30-minutes appointments. Some of the patients take more or less than 30 minutes depending on the type of dental work to be done. The following summary shows the various categories of work, their probabilities and the time actually needed to complete the work.

Category	Time Required	Probability

Filling	45 min	0.40
Crown	60 min	0.15
Cleaning	15 min	0.15
Extraction	45 min	0.10
Check Up	15 min	0.20

Simulate the dentist's clinic for four hours and determine average waiting time for the patients as well as the idleness of the doctor. Assume that all the patients show up at the clinic at exactly their scheduled arrival time starting at 10 a.m. Use the following random numbers for handling the above problem: 40, 82, 11, 34, 25, 66, 17, 79 (6 marks)

(b)

Category	Time Required	Probability
Filling	45min	0.40
Crown	60min	0.15
Cleaning	15 min	0.15
Extraction	45 min	0.10
Check-Up	15 min	0.20

Solution

Step 1 => Finding the cumulative probability distribution of each work category

✓Filling = 0.40 ✓Crown = 0.40 + 0.15 = 0.55

✓Cleaning = 0.55 + 0.15 = 0.70 ✓Extraction = 0.70 + 0.10 = 0.80

✓Check-Up = 0.80 + 0.20 = 1

Step 2 => Define random number intervals of each category with respect to their cumulative probability

Random numbers = [40, 82, 11, 34, 25, 66, 17, 79]

Category	Time Require	Probability	Cumulative probability	Random numbe Interval
Filling	45min	0.40	0.40	00 - 39
Crown	60min	0.15	0.55	40 - 54
Cleaning	15 min	0.15	0.70	55 - 69
Extraction	45 min	0.10	0.80	70 - 79
Check Up	15 min	0.20	1	80 - 99

Step 3 => use the random number to do the simulation

✓ Appointment time = 30 mins per patient } $\frac{240}{30}$ = 8 patients

✓ Simulation duration = 4hrs (240 mins)

✓ Random number = 40, 82, 11, 34, 25, 66, 17, 79

Patient	Schedule Arrival	Random Numbers	Category using random numbers	Service time needed
1	10.00a.m	40	Crown	60min
2	10.30a.m	82	Check Up	15min
3	11.00a.m	11	Filling	45min
4	11.30a.m	34	Filling	45min
5	12.00a.m	25	~~Cle~~ Filling	45 min
6	12.30a.m	66	Cleaning	15 min
7	1.00a.m	17	Filling	45 min
8	1.30a.m	79	Extraction	45 min

Patient	Schedule Arrival	~~Rand~~ Service start time	Service duration (mins)	Service end-time	waiting time (min)	idle time (min)
1	10.00a.m	10.00a.m	60	11.00a.m	0min	0 min
2	10.30a.m	11.00a.m	15	11.15a.m	30min	0 min
3	11.00a.m	11.15a.m	45	12.00p.m	15min	0 min
4	11.30a.m	12.00p.m	45	12.45p.m	30min	0 min
5	12.00a.m	12.45p.m	45	1.30p.m	45min	0 min
6	12.30a.m	1.30p.m	15	1.45p.m	60min	0min
7	1.00a.m	1.45p.m	45	2.30p.m	45min	0min
8	1.30a.m	2.30p.m	45	3.15p.m	60min	0min

Average waiting time = $\frac{\text{Sum of waiting time}}{\text{no of patients}}$

= $\frac{(0+30+15+30+45+60+45+60)\text{mins}}{8} = \frac{285}{8}$

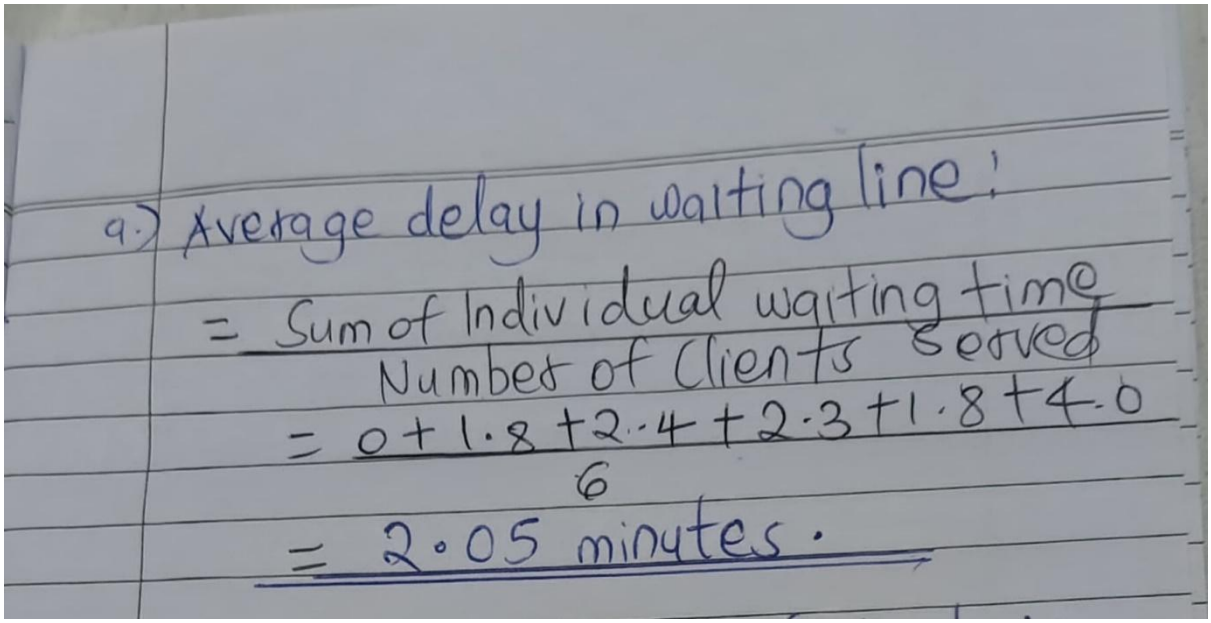
= 35.625 mins

Idle time of the doctor = 0 mins

c) Consider a simple server queuing system that starts at time t=0. The arrivals occur at times 1.2, 1.8, 2.6, 3.8, 6.0, 6.2, 7.0, 7.5, 8.6, and 0.2. Departures occur at times 3.0, 4.2, 4.9, 5.6 and 10. Time is in minutes. Simulate this Queuing System until when the sixth client enters service and estimate: (10 marks)

i. The average delay in the waiting line

ARRIVAL TIME	EVENT	DEPARTURE TIME	TIME TAKEN	DELAY TIME
0·2	Customer 1 Arrives	3·0	2·8	0
1·2	Customer 2 Arrives	4·2	3·0	3·0 - 1·2 = 1·8
1·8	Customer 3 arrives	4·9	3·1	4·2 - 1·8 = 2·4
2·6	Customer 4 arrives	5·6	3·0	4·9 - 2·6 = 2·3
3·8	Customer 5 arrives	10·0	6·2	5·6 - 3·8 = 1·8
6·0	Customer 6 arrives	-		10 - 6·0 = 4·0
6·2	Customer 7 arrives	-		
7·0	Customer 8 arrives	-		
7·5	Customer 9 arrives	-		
8·6	Customer 10 arrives	-		



ii. The average number of clients in the waiting line at any time

iii. The server utilization rate

The solution for questions ii and iii are as attached in the below image:

(b) Average number of clients in waiting line at any time.

Arrival time	Departure time	No of clients waiting
0.2	3.0	0
1.2	4.2	3
1.8	4.9	2
2.6	5.6	1
3.8	10	1
6.0	–	–

Average no of client waiting $= \frac{0 + 3 + 2 + 1 + 1}{5}$

$= \frac{7}{5}$

$= \underline{1.4}$

(c) The server utilization rate

A.T	D.T	W.T	Service Time
0.2	3.0	0	2.8
1.2	4.2	1.8	1.2
1.8	4.9	2.4	0.7
2.6	5.6	2.3	0.7
3.8	10	1.8	4.4
6.0	–	4.0	–

Server utilization rate $= \frac{\text{Time Server is Busy}}{\text{Total Time observed}}$

$= \frac{2.8 + 1.2 + 0.7 + 0.7 + 4.4}{6.0}$

$= \underline{1.633}$